Lake Washington General Investigation Study Monitoring Review Workshop

Title: Juvenile and Adult Fish Passage at the Hiram M. Chittenden Locks
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The purpose for this presentation is to provide an overview of recent fish passage monitoring at the Hiram M. Chittenden Locks. The presentation is broken into two parts – juvenile and adult monitoring. Contributors to this presentation include D. Seiler and K. Fresh, Washington Department of Fish and Wildlife (WDFW); P. Johnson and M. Hanks, Mevatek; P. DeVries, R2 Resource Consultants; M. Timco, Hydroacoustic Technology Inc.; J. Dawson, BioSonics; and D. Houck, King County.

Juvenile Fish Passage. Monitoring of juvenile salmon (smolt) passage at the Locks has been ongoing since 1994. We will report on results for 2000 and 2001. Description of monitoring methods are available in separate reports, see http://www.nws.usace.army.mil/ers/Monitoring.cfm. Juvenile salmon may pass through the Locks through one of 12 different routes or pathways. We monitored four of these pathways during 2000 and 2001. Results are broken into the following areas 1) entrainment into the large lock filling culverts; 2) observer counts of smolts passing over flumes; 3) fish guidance efficiency (FGE) – percent of smolts using one of two pathways – the flumes or large lock culverts; and 4) monitoring of other pathways – the saltwater drain and spillway bay number 2.

Juvenile Results Summary. *Entrainment Reduction by Slow Fill.* Purse seine catch suggests a trend with lower entrainment rates with slower fill rates. Hydroacoustic estimates show no discernable difference between the two slowest fill types (mean value of 29.3 fish/fill for graduated and 29.8 fish/fill for intermediate). Both methods indicate entrainment rates are within the same range. *Barnacle Removal*. Injury rate for heavily descaled smolts is 75% lower since barnacle removal (removal occurred in November 1999) and 65% lower for lightly descaled fish. *Smolt Passage Flumes.* In a single day up to 45,000 smolts can be passed over the flumes vs. a peak entrainment of 1,000 fish through the large lock culverts. PIT-tagging results show a peak in juvenile chinook passage in mid to late June for 2000 and 2001. In 2001, the peak passage period for wild Bear Creek and Cedar River chinook coincided with the decline in available water for spill. Observer counts likely underestimate the actual number of smolts passing through the larger flumes. Smolt capture below the flumes offers the potential for a wide range of new data. A pilot effort in 2001 by WDFW to capture smolts below the flumes indicated observer counts may be fairly accurate for the smallest flume (4A) but may be underestimating counts for the largest flumes (5B, 4B) by 2-3 times. Smolt capture methods will likely require an involved feasibility assessment. *Fish Guidance Efficiency.* Adequate flow volume through the flumes is largely responsible for the reduced entrainment rate through the large lock culverts. Over the range of flume volume discharges (50-405 cfs) we have observed 1) over 96% of counted smolts pass over the flumes when flow volumes are greater than 260 cfs; 2) between 131 to 260 cfs approximately 92% of smolts pass over the flumes; and 3) at flows less than 130 cfs there is an almost even passage rate with 50% of smolts using the flumes and 50% entrained in the large lock culverts. *Saltwater Drain.* Few smolts are entrained during periods of spill or smolt passage flume operation. Estuarine fish are the most entrained fish with the highest entrainment rates in late August and September. Adult chinook enter the area of the drain intake and may hold for short periods but are able to swim-out during normal summer conditions. *Spillway Gate.* The estimates of fish passage through spillway gate number 2

suggest increased passage at a 12-inch gate height vs. 6 inch. Estimates were 100 to 150% higher for the 12-inch gate opening, requires conversion to fish/cfs. The minimum gate opening previously used at the locks was 6 inches (this opening did not incorporate an objective to pass juvenile salmon).

Adult Fish Passage. The Corps monitored adult chinook salmon behavior in areas of the Ship Canal above the Locks in 1999 and 2000. We (the Corps/HTI) will report on results from year 2000. Beginning in 1998, the WDFW, Muckleshoot Tribe, and King County utilized biotelemetry, ultrasonic or acoustic tags, to track adult chinook from the Locks to spawning grounds in throughout the Lake Washington basin. We conducted intensive monitoring within the vicinity of the Locks using two acoustic tracking systems 1) in 1999 we used standard acoustic tracking (Vemco equipment) with single fixed station receivers augmented by mobile tracking from land and boat. Fish tracking using these standard methods allows detection of fish within a fairly large horizontal area, 100-500 ft, vertical position is only available for fish tagged with a pressure transducer. Monitoring in 1999 indicated adult fish were holding in a very localized area just upstream of the large locks and saltwater drain (coolwater refuge); and 2) in 2000 we employed Hydroacoustic Technology Inc. (HTI) to conduct the first study in brackish water conditions using an improved acoustic tracking system, a linked hydrophone array (nine hydrophones monitoring fish position simultaneously) allowing observations of fish position (horizontal and vertical) with a high level of accuracy, HTI states $\pm$ 1-m. Between July 23 to August 25, WDFW/MIT personnel tagged 45 adult chinook with a combined HTI and Vemco tag. HTI monitored fish position above the Locks from July 24-October 2. Coincident with fish tracking, we maintained a series of water quality sensors over the top of the saltwater drain intake measuring temperature, conductivity, salinity and dissolved oxygen (hourly) at a series of depths.

Preliminary Results. Adult salmon behavior has not been studied before in such an unusual pseudo-estuary. Virtually all tagged fish remained within a very localized area just upstream of the large locks and the saltwater drain intake (coolwater refuge). Adult chinook maintained a mean position of 7.0 to 7.4 m depth between July 29-August 25. Fish position (all data points – a.ka. "data cloud") created a shape akin to a funnel or plume where the open end of the funnel is largest at the downstream end (25 ft upstream of the saltwater drain intake) narrowing in an upstream direction. The mean fish depth corresponds to water quality values of 1) temperatures of 20.5-21.5 ^{o}C; 2) dissolved oxygen levels of 6.8-7.5 mg/l; and 3) salinity levels of 0.6-1.2 ppt. These preliminary results were unexpected – 1) fish holding in high water temperatures, 21 to 21.5 C (reported elsewhere as beyond the selected range of adult chinook), and 2) the possibility that adult holding behavior may be a function of acclimation to freshwater. What does this long-term temperature exposure mean to reproductive success? These initial results as yet do not show that the coolwater refuge is a necessary habitat feature explaining fish location and behavior: water quality conditions (for temperature, salinity, and dissolved oxygen) further upstream are within the range of those fish were holding in at the Locks and are accessible. Further analysis will include water velocity tracks and analysis of fish position during Locks operations. Lastly, we have asked Waterways Experiment Station to further evaluate fish behavior by investigating development of a computational fluid dynamics model relating fish location to changing water quality conditions.